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Title: STRUCTURAL MEMBER.

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Applicant(s): WARD BUILDING SYSTEMS LTD (GB)

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Priority Number(s): GB19900017152 19900803; GB19910006250 19910323

IPC Classification: E04C3/07

Equivalents:

ABSTRACT:

A structural member of the kind specified wherein at least one of the flanges has a reinforcing formation at least at one edge, the reinforcing formation comprising a generally closed section connected to the one edge of the respective flange.

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(51) INT CL[5]
E04C 3/07

(52) UK CL (Edition K)
E1D DCA D1074 D2103 D402 D501

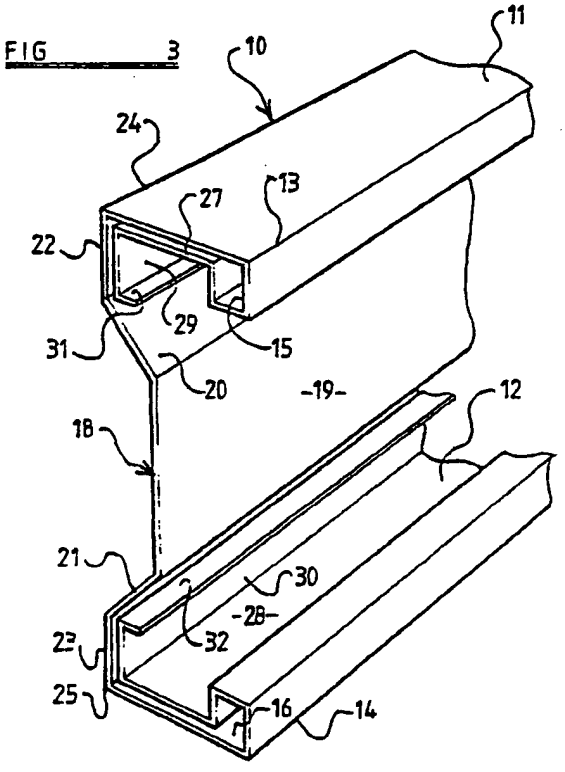
(56) Documents cited
GB 2093886 A

(58) Field of search
UK CL (Edition J) E1D DCA DCB
INT CL[4] E04C

(54) Elongate cold-formed structural member, e.g. a purlin

(57) A structural member having a pair of spaced generally parallel flanges 11, 12 being reinforced at one edge 13, 14 and interconnected by a web 18 at their other edges 24, 25, the web 18 having a median portion 19 generally orthogonal to the flanges but offset from their edges, is characterized in that at least one flange has a reinforcing portion in the form of a generally closed section 15 at one edge. Section 15 may be almost closed, as shown, or may be actually closed, and may be of square, oblong, triangular or circular cross-section; either or both of the flanges and webs may have reinforcement in the form of depressed or raised channels and the like; the flanges may be both on the same side of the web as shown, or on opposite sides.

FIG 3



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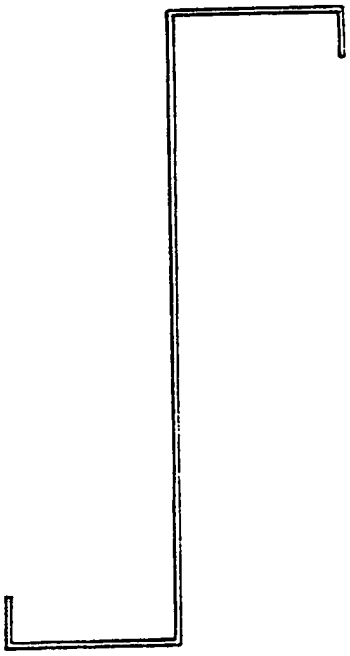


FIG 1a

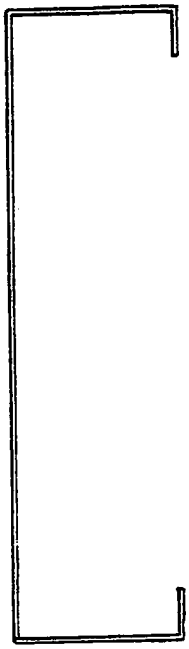


FIG 1b

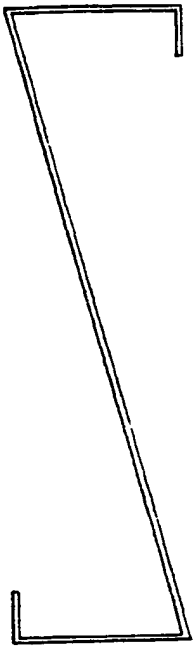


FIG 1c

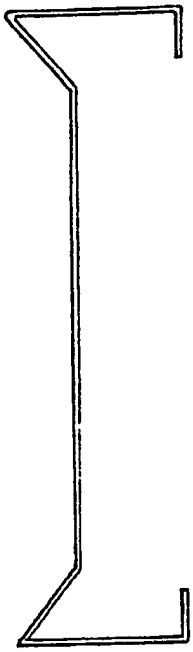


FIG 1d

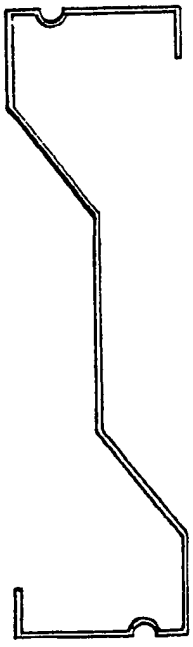


FIG 1e

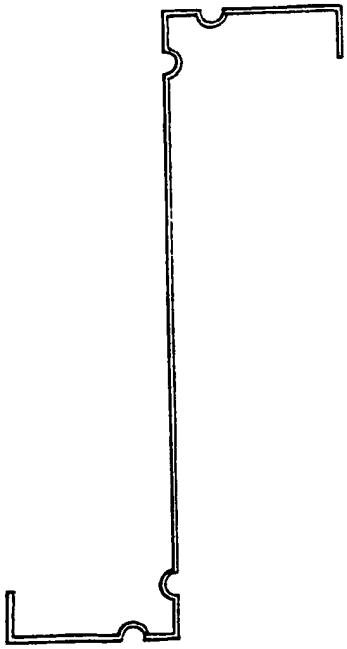


FIG 1f

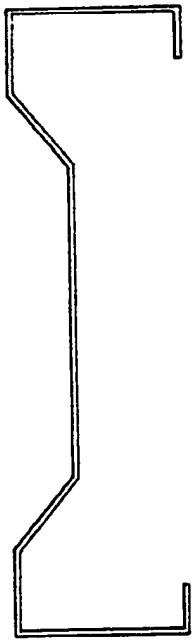


FIG 1g

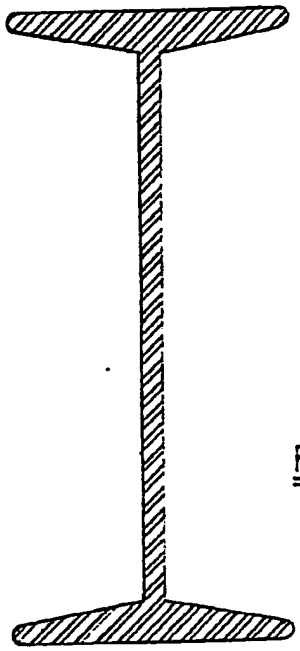


FIG 2

FIG 3

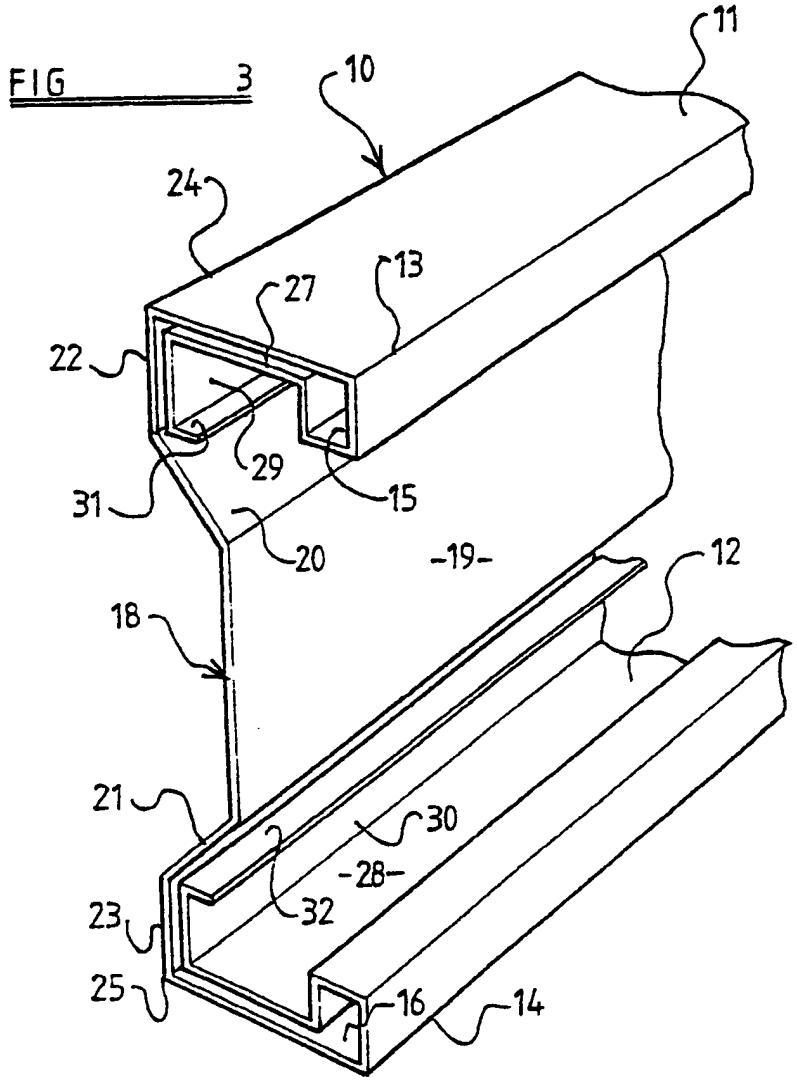


FIG 4

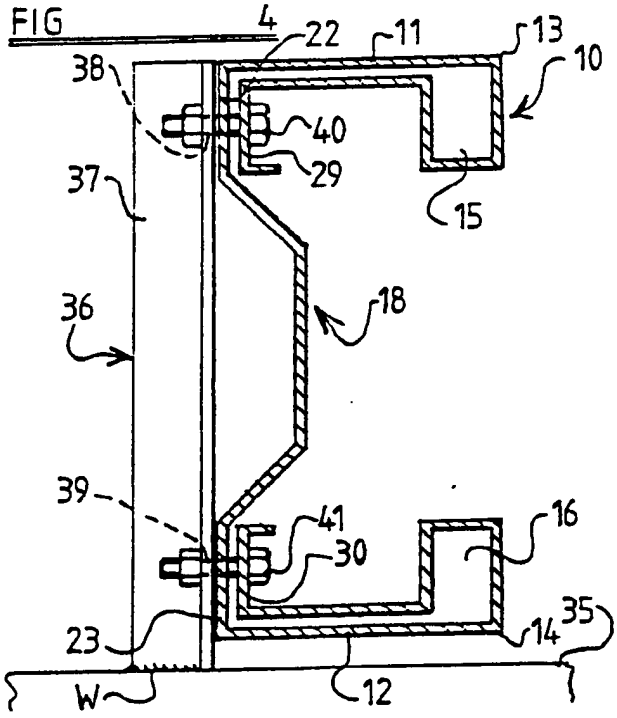


FIG 5

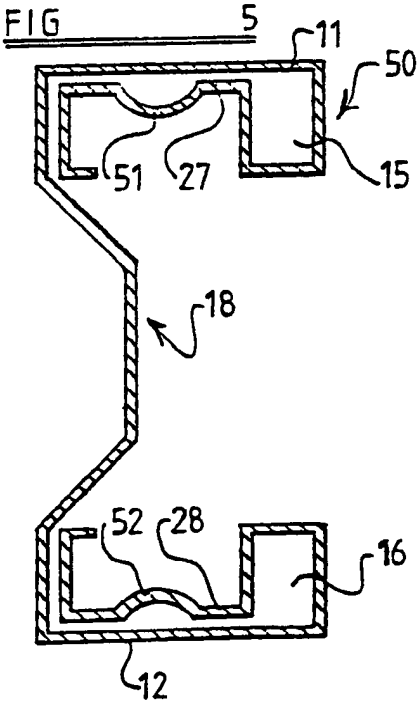


FIG 6a

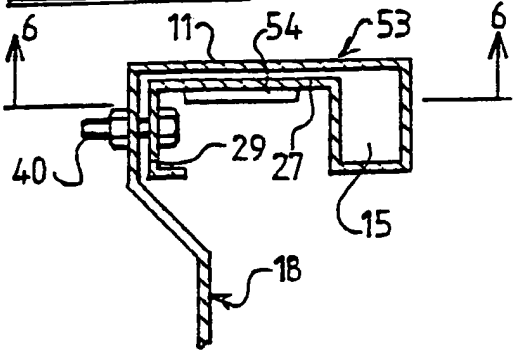


FIG 6b

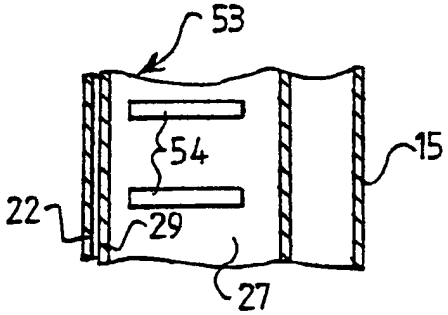


FIG 7a

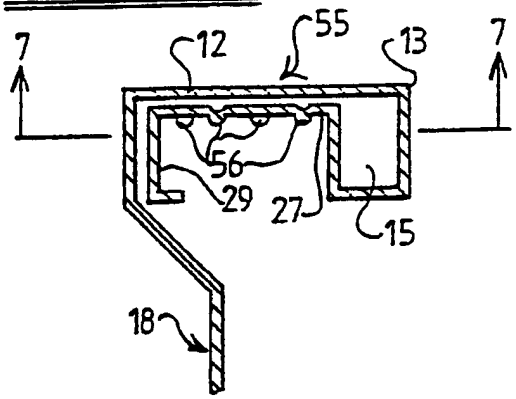


FIG 7b

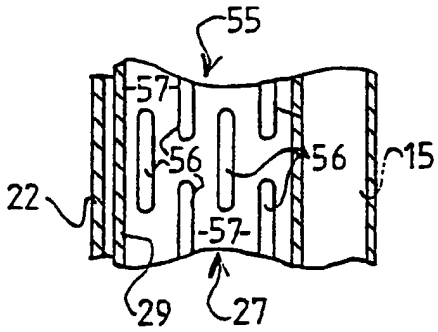


FIG 8a

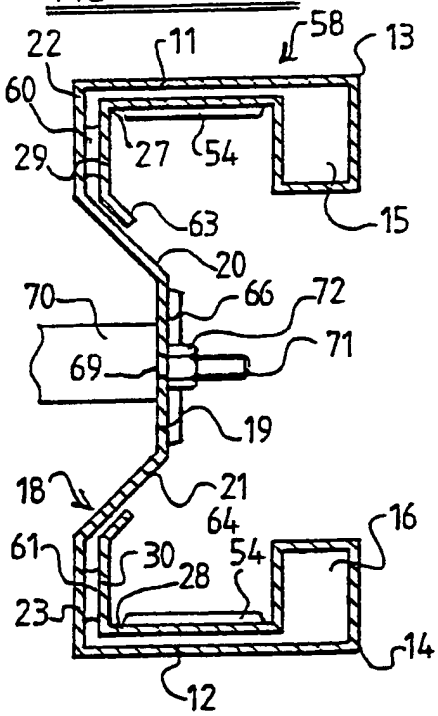


FIG 8b

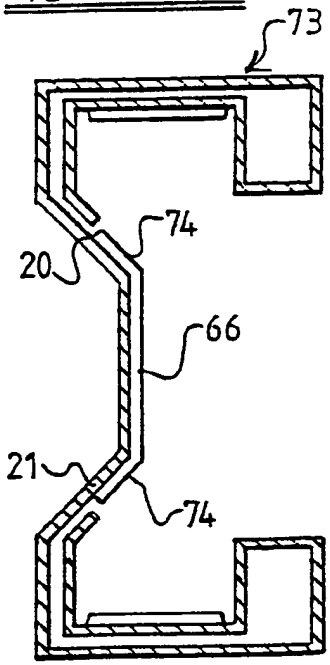


FIG 8c

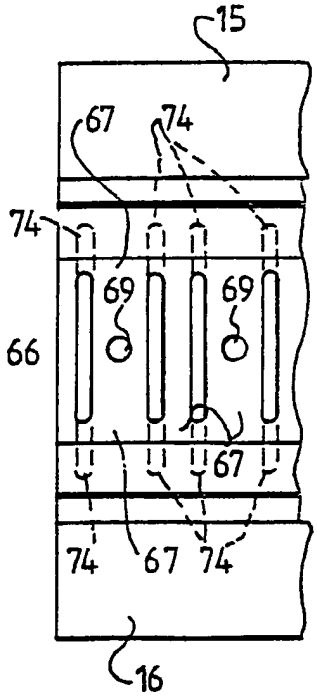


FIG 9

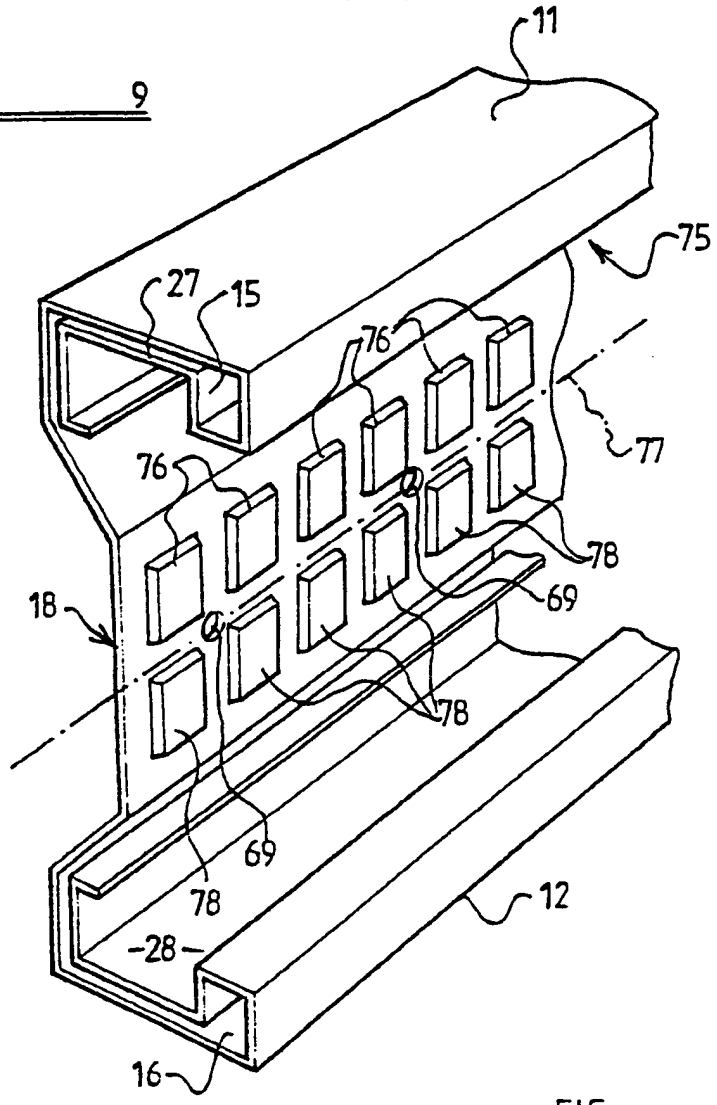


FIG 10

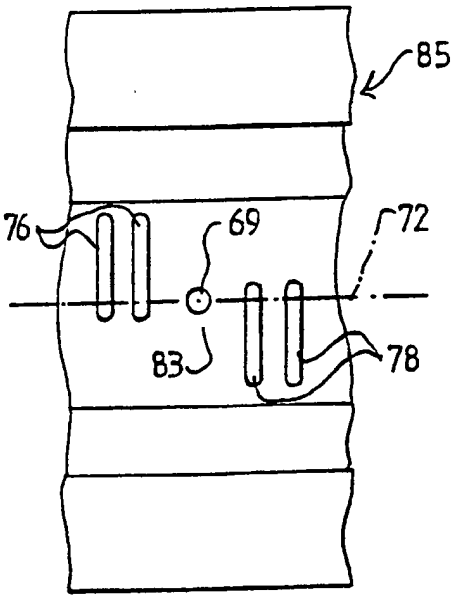
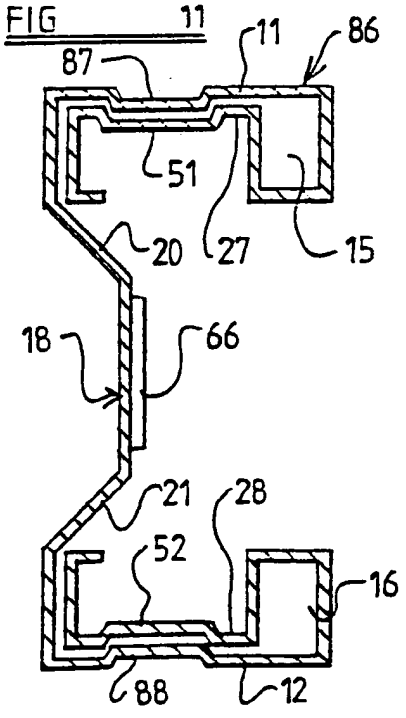


FIG 11



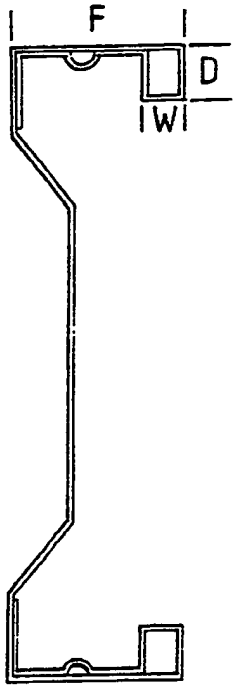


FIG 12a

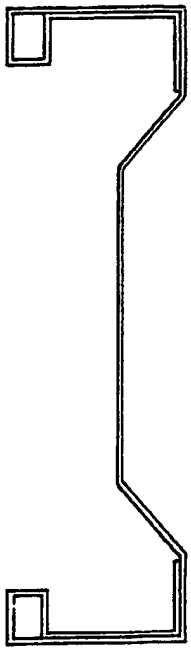


FIG 12b

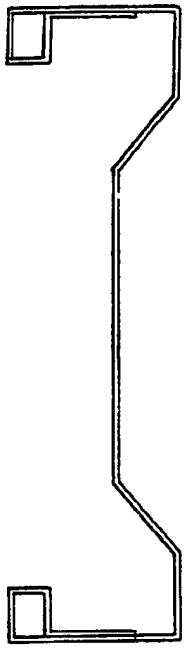


FIG 12c

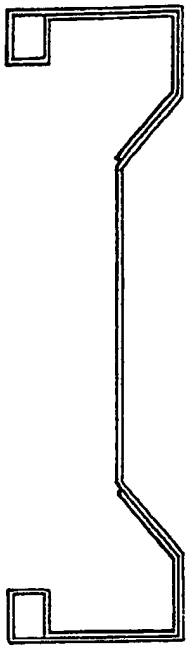


FIG 12d

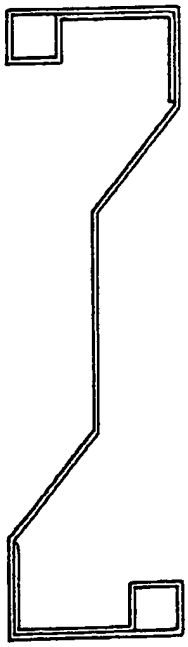
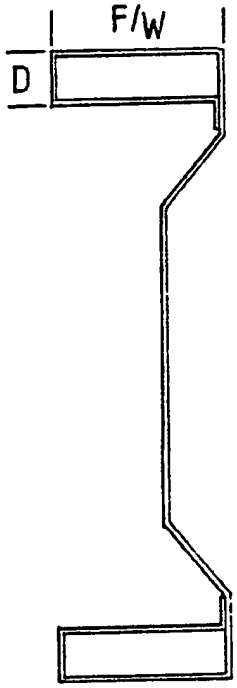


FIG 12e



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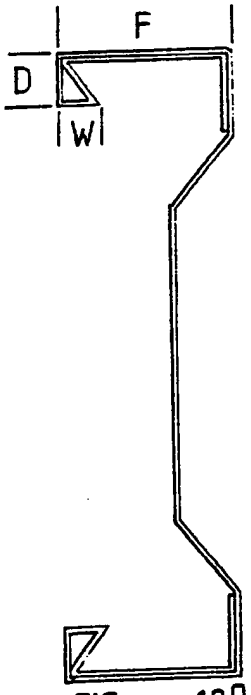

FIG 12g

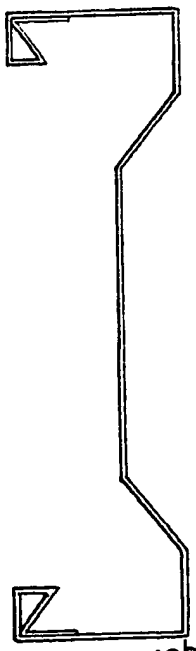

FIG 12h

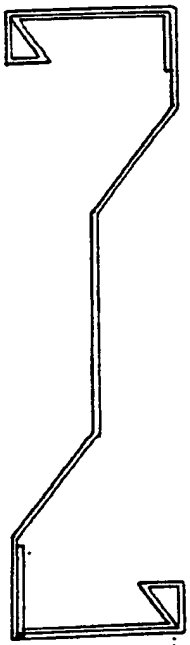

FIG 12i

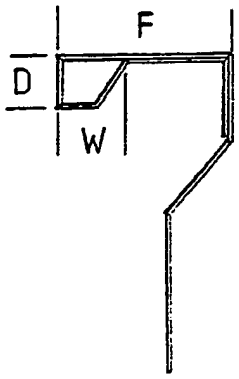

FIG 13a

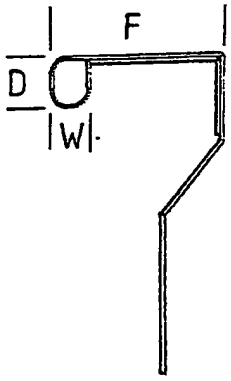

FIG 13b

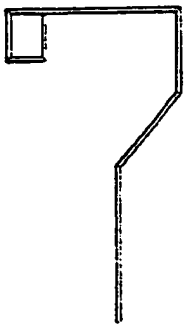

FIG 14a

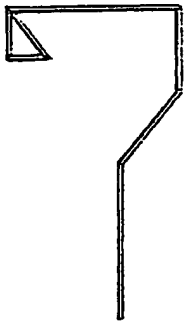

FIG 14b

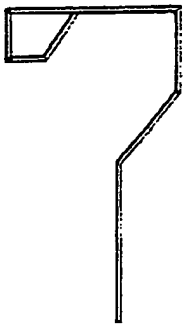

FIG 14c

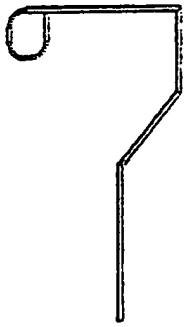

FIG 14d

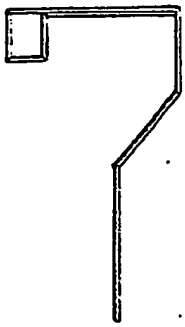

FIG 15a

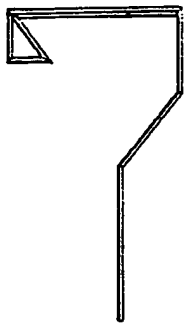

FIG 15b

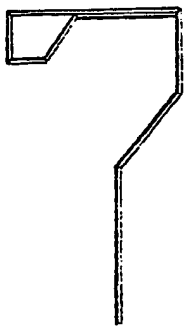

FIG 15c

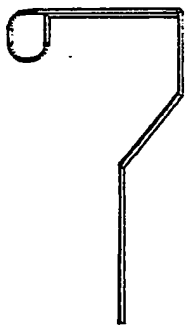

FIG 15d

Title: "Structural member"

Description of Invention

This invention relates to a structural member and more particularly, but not exclusively, to a structural member comprising a purlin, for example, for a roof structure.

Known structural members, such as purlins and rails, made by cold rolling strip material, have several limitations. Figures 1a - g show the cross-sectional shape of six commonly used structural members. All the members are of a uniform material thickness. This has the effect that when the members are subjected to bending in a vertical plane, i.e. about a horizontal axis, the material of the flanges at top and bottom are relatively highly stressed whilst much of the vertical web areas are relatively lowly stressed. For this reason hot rolled members such as that shown in Figure 2 are used since they can be provided with more material thickness in the flanges than in the web, and so are more efficient and thus achieve material economies. This factor limits the maximum useful span and load conditions where the cold formed members can be used.

In addition, such known cold formed members have been connected to cleats by means of holes through thin central web areas. This can cause local bearing failures when the member is loaded.

Also, it had not been appreciated how important is the location of bolt holes in the web if maximum performance is to be gained. Our patent GB-B-2131467 indicates how significantly improved performance can be achieved if the section is held near to the top and bottom.

There have been a number of recent attempts to improve the performance of cold formed members. These relate to the inclusion of stiffening ribs in the flanges

and, sometimes, in the web as shown in Figs. 1e, f, and g. This approach does not provide a significant improvement in the area where cold formed members are economic against the hot rolled but gives marginal improvements over the cross-sectional shapes shown in Figs. 1a - d. In addition flanges with such ribs can cause difficulties if self drilling fasteners are used.

Thin gauge cold formed members, such as purlins, under load can fail by local buckling if compressive stresses are too high (possibly at stresses well below material yield stress) or by deflection, distortion or rotation beyond acceptable limits. For this reason, careful attention has to be paid to their support and restraint by means of tie rods or by cladding supported by the members. To assist in reducing the level of restraint and support required, consideration must be given to the load path and the position of the members "shear centre", i.e., the point where a load must be applied to the member to avoid twisting of the member. In addition, certain cross-sections, particularly zed sections, can generate very high forces in the plane of cladding supported on the top flange of the member because of shear force distribution around the member and thus fail due to lateral and/or torsional instability. [US-A-4,409,771 which shows connection of the flanges to a support member.]

Simple channel sections can generate very high twisting forces when loaded normal to the top flange.

The position of the shear centre therefore has considerable influence on the restraint that must be applied to a member such as a purlin or rail if it is to perform well under load. To bring the shear centre more into line with the load path from the top flange the members shown in Figures 1e and 1g and the member described in GB-B-2131467 comprises a structural member having a pair of spaced generally parallel flanges, each having a

reinforcing formation at one edge, and the flanges being interconnected by a web at their other edges, the web comprising a median portion perpendicular to the flanges and connected by intermediate portions to edge portions of the web which are connected to the other edges of the flanges to extend generally perpendicularly thereto, the median portion of the web being disposed intermediate the one and other edges of the flanges and being offset from the edge portions of the web. Such a structural member will hereinafter be referred to as being "of the kind specified".

Any other means of manipulating the shear centre into the load path is also desirable to improve stability without the need for a lot of restraint.

The invention is intended to remedy the drawbacks of known structural members.

According to one aspect of the present invention we provide a structural member of the kind specified wherein at least one of the flanges has a reinforcing formation at least at one edge, the reinforcing formation comprising a generally closed section connected to the one edge of the respective flange.

The flanges may comprise side by side generally opposed flanges disposed on the same side of the web.

Alternatively the flanges may comprise flanges disposed on opposite sides of the web.

The load bearing capability of the structural member overall is increased by virtue of the reinforcing formation comprising a closed section which is stronger and more stable than, for example a simple lip. In addition the provision of the closed section enables the shear centre to be manipulated into line with or towards the load path.

In a preferred arrangement, the closed section extends generally throughout the length of the structural

member and may be a square or rectangular box section. Alternatively the closed section may be of any other desired shape such as circular, oval, triangular or trapezoidal in cross section.

Preferably the maximum depth of the reinforcing formation lies in the range 10 - 30% of the width of the flange and/or the maximum width of the reinforcing formation lies in the range 8 - 25% of the width of the flange.

Preferably the reinforcing formation is of greater width at a position spaced from the flange than it is at the flange.

The reinforcing formation may define a groove between the flange and the surface of the reinforcing formation which is closest to the web.

The reinforcing formation may comprise a first portion which extends from the associated flange generally towards the other flange, a second portion which extends from the first portion at the end thereof remote from the associated flange towards the web and a third portion which extends from the end of the second portion remote from the first portion towards the associated flange.

One or more of the above mentioned portions may be rectilinear or curvilinear in cross-section and where a portion is rectilinear it may extend at right-angles to the associated flange or adjacent the portion or be inclined thereto at other than 90°.

Preferably the first and second portions are rectilinear and extend at 90° to the associated flange and the first portion respectively whilst the third portion is rectilinear and is inclined to the second portion at an acute angle.

Preferably the third portion extends from the second portion to a position adjacent the associated flange which is adjacent the position at which the first portion

leaves the associated flange. With such a shape a groove is defined between the flange and the third portion and the reinforcing formation is of greater width at a position spaced from the flange, i.e. in the plane of the second portion, than it is at the flange, i.e. at the position at which the first and third portions join the flange.

The closed section reinforcing formation may be connected to a reinforcing portion at least a part of which extends generally adjacent and parallel to the respective flange.

Preferably both of the flanges have a reinforcing formation comprising a generally closed section at their respective one edges.

Each reinforcing formation may be connected to a reinforcing portion.

By providing a reinforcing portion the strength of the respective flange generally may be increased.

The reinforcing portion may comprise a double thickness flange or flange and web part. As a result metal is put into the most highly stressed areas whilst saving a significant amount of material in the majority of the web whilst maintaining adequate thickness for connections into web parts adjacent to the flanges where the reinforcing portion is provided for the web parts.

In contrast, the known single thickness purlins, Figs. 1(a) to (g) inclusive, will all fail in bending by a buckle forming in the flange immediately after the stiffening lip moves sideways.

The reinforcing portion may comprise a part of the reinforcing formation.

Where the reinforcing formation comprises a rectangular box section one side of the box may be provided by the flange and an opposite side of the box by the reinforcing portion.

Each of the flanges may have an associated reinforcing portion.

The or each reinforcing portion preferably terminates in the region of the connection between the edge portions and the connected inclined portions of the web.

The reinforcing portion may comprise integral stiffening.

The integral stiffening may be provided by one or more stiffening formations comprising ribs which extend longitudinally of the structural member generally over the entire length thereof.

Alternatively, the integral stiffening may be provided by stiffening formations comprising transversely extending ribs, or by an array of stiffening formations arranged in any desired pattern over the reinforcing portion.

The or each of the stiffening formations may be provided by material of the reinforcing portion deformed out of the plane of the remainder of the reinforcing portion in an eventual direction preferably away from the adjacent flange.

Preferably the reinforcing portion extends generally adjacent and parallel to the respective flange, along the side of the flange facing inwardly of the structural member.

Alternatively, the reinforcing portion may extend generally adjacent and parallel to the respective flange along the side of the flange facing outwardly of the structural member.

The reinforcing portion may terminate at an edge adjacent the respective flange, but preferably, the reinforcing portion comprises an extension part which extends generally adjacent and parallel to a part of the web.

The extension part preferably extends throughout the full depth of the associated edge portion of the web, thus terminating at or adjacent the junction of the web edge and intermediate portions.

The reinforcing portion may terminate in an inturned lip if desired.

The reinforcing portion may be connected to the respective flange or to the web if desired. For example where an extension part is provided, this may be secured to the web by riveting, clinching, or stitching.

Further alternatively, where the structural member is a purlin secured to a further transversely extending structural member by a cleat, the extension part of the reinforcing formation may be secured to the web by a fastener which fastens the cleat to the purlin.

It will be appreciated that with a structural member according to the first aspect of the invention, it is possible to increase the load bearing capability of the structural member without increasing the thickness of the material from which it is made. This is achieved particularly because of strengthening of the flange or flanges and/or web part(s).

If desired, for example, where loads and spans are such that the thinner webs are susceptible to distortion or buckling, the thin metal in these areas may be strengthened by providing integral stiffening. This may be localised around connections, such as sag rods or cleat and sleeve connections or may be throughout the length of the member. The web may be provided with integral stiffening.

Strengthening of the web may be achieved by providing stiffening formations which are deformed out of the plane of at least the median portion of the web.

The integral stiffening may comprise one or more stiffening formations comprising ribs which extend generally throughout the length of the structural member

along the median portion, or alternatively may comprise a series of ribs arranged transversely of the longitudinal extent of the structural member.

Preferably the integral stiffening comprises a first set of stiffening formations arranged generally to one side of a plane of symmetry of the structural member, and a second set of stiffening formations arranged generally to the other side of the plane of symmetry of the structural member. A space may be provided generally between the first and second sets of integral stiffening formations in which may be provided openings to enable for example tie rods, where the structural member is a purlin, to be secured to the structural member, for example, as described in our prior British Patent GB 2097038, or otherwise.

Alternatively, the integral stiffening may be provided by an array of stiffening formations provided at least in the median portion of the web, there being areas generally along the plane of symmetry of the structural member where no stiffening formations are provided, but in which apertures are provided through the median portion of the web, for example again to enable tie rods to be secured to the structural member where the structural member is a purlin.

Preferably the flange has a portion which extends over at least 60% of the total flange width which is of single thickness or of double thickness with the inner and outer flange parts in the double thickness region in contact or closely adjacent, i.e. not spaced by more than that which prevents self-drilling, self-tapping fasteners being satisfactorily used, for example, not more than 3 - 4mm or are spaced by more than prevents self-drilling, self-tapping fasteners being satisfactorily used, e.g. more than about 15mm.

Each intermediate portion may be inclined at 90° to the edge portion and the median portion. Alternatively, each intermediate portion may be inclined at an obtuse angle to the edge portions and the median portion. Preferably the obtuse angle lies in the range 160° to 150° and is most preferably 157°.

Preferably the structural member is of non-welded construction so as to permit of the use of surface treated material such as galvanised steel without damage being caused by welding.

According to a second aspect of the invention we provide a structure comprising at least two support members and a structural member according to the first aspect of the invention supported by and extending between the support members and being connected to each of the support members by cleats, one cleat being fixed to each of the two support members.

The structural member is connected to a load bearing member by fasteners which are engaged with a reinforcing portion of the structural member.

The load bearing member may comprise a cleat, a rafter stay, a joining sleeve or any other member for taking loads into or out of the structural member.

The load bearing member may be fastened to the structural member by fasteners which are engaged with the edge portions of the web of the structural member.

In the accompanying drawings:

FIGURES 1a to g show seven previously known cold rolled structural members,

FIGURE 2 is a diagrammatic cross-section through a previously known hot rolled structural member.

FIGURE 3 is a perspective view of part of a structural member in accordance with the first aspect of the invention,

FIGURE 4 is an end sectional view of the structural member of Figure 3 secured to a structure by cleats,

FIGURE 5 is an end sectional view through a second embodiment of a structural member in accordance with the invention,

FIGURE 6a is an end sectional view through part of another embodiment of a structural member in accordance with the invention,

FIGURE 6b is a cross sectional view on the lines 6-6 of the structural member of Figure 6a,

FIGURE 7a is a view similar to Figure 6a but showing a yet further alternative structural member,

FIGURE 7b is a cross sectional view on the lines 7-7 of Figure 7a,

FIGURE 8a is an end sectional view of a structural member similar to that shown in Figure 6a, but modified, and connected to a tie rod,

FIGURE 8b is a view similar to Figure 8a but of a further modified structural member,

FIGURE 8c is a side view of part of the structural member of Figures 8a or 8b,

FIGURE 9 is a perspective view of a still yet further embodiment of a structural member in accordance with the invention,

FIGURE 10 is a an underneath plan view of part of another structural member in accordance with the invention,

FIGURE 11 is an end sectional view of a still yet further structural member in accordance with the invention.

FIGURES 12a - j are diagrammatic cross-sectional views through further embodiments of the invention,

FIGURE 13a and FIGURE 13b are fragmentary cross-sectional views showing two further embodiments of the invention where there is a reinforcing portion associated with each flange and adjacent web portion,

FIGURES 14a - d are fragmentary cross-sectional views through four further embodiments provided only with reinforcing formations,

FIGURES 15a - d are fragmentary diagrammatic cross-sectional views through four further embodiments of the invention showing a reinforcing formation and a reinforcing portion provided for each flange,

Referring first to Figure 3, a structural member 10 comprises a pair of spaced side by side generally parallel opposed flanges 11 and 12 which each have along their one edges 13,14, respectively, a reinforcing formation 15,16, which in the present example, comprise substantially closed box sections, although could be of another generally closed sectional configuration as desired, such as tubular (round), triangular, or even trapezoidal cross section.

The flanges 11 and 12 are interconnected by a web 18, the web comprising a median portion 19 which is generally perpendicular to the flanges 11 and 12, the median portion 19 being connected by inclined portions 20 and 21 to edge portions 22,23, of the web 18, the edge portions of the web 18 being connected to the other edges 24,25, of the flanges 11,12. The edge portions 22 and 23 extend generally perpendicularly to the flanges 11 and 12, and the median portion 19 of the web 18 is thus disposed intermediate the edges 13,24, and 14,25, of the flanges 11,12, and is offset from the edge portions 22,23 of the web 18.

The structural member 10 is made by cold rolling and connected to the box sections 15 and 16 are respective reinforcing portions 27 and 28, at least parts of which extend generally adjacent and parallel to the respective flanges 11,12.

Extension parts 29 and 30 of the reinforcing portions 27 and 28 extend generally adjacent and parallel to respective edge portions 22,23, of the web 18, and

terminate in the regions where the inclined portions 20 and 21 are connected to their respective edge portions 22,23, as an inturned lip 31,32.

By providing the closed sections 15,16, at the one edges 13,14, of the flanges 11,12, the flanges 11,12 are strengthened, and the reinforcing portions 27,28, add further strength generally to the flanges 11 and 12.

Referring now also to Figure 4, there is shown a structure comprising the structural member 10, and a plurality of supporting members 35, only one of which is seen.

The structural member 10 is secured to at least two supporting members 35 by means of cleats 36, which in this example are welded (at W) but could be otherwise fixed to the supporting members 35.

The cleats 36 have stiffening ribs 37 between which are provided openings 38 and 39 through which fasteners 40 and 41 pass, openings being provided in the respective extension portions 29,30 and edge portions 22 and 23 of the structural member 10 to receive the fasteners 40 and 41.

Referring now to Figure 5, a structural member 50 similar to that shown at 10 in Figures 3 and 4 is shown, and similar parts to the structural member 10 of Figures 3 and 4 are indicated by the same reference numerals.

The reinforcing portions 27 and 28 of the structural member 50 in Figure 5, are each provided with integral stiffening comprising a single stiffening formation 51,52, comprising a rib which extends longitudinally generally throughout the entire length of the structural member 50.

The rib 51,52 is provided by outwardly deforming a portion of the reinforcing portion 27,28, during cold rolling of the beam 50.

As indicated, the ribs 51,52, are of curved configuration, but could be of trapezium form, or of any other generally channel shaped configuration as desired.

It will be appreciated that instead of providing a single rib 51, 52, on each reinforcing portion 27,28, which extends generally throughout the entire length of the structural member 50, a plurality of such longitudinally extending ribs may be provided in the reinforcing portions 27,28, if desired.

The rib or ribs further delay the onset of flange buckling. They still permit a self drilling fastener to be applied to the outer flange without the risk of it being deflected to an angle other than 90° to the flange, as this can easily happen with profiles (a) and (f) in Fig. 1 and this can cause leakage around fasteners.

Referring now to Figures 6a and 6b, a structural member 53 is shown, similar parts to the structural members of the preceding figures again being labelled with the same reference numerals.

In this embodiment, integral stiffening comprising stiffening formations are provided in the reinforcing portions 27 and 28 of the structural member, the stiffening formations comprising a series of ribs 54 which extend transversely of the longitudinal extent of the structural member 53, the ribs 54 extending across the reinforcing portions 27,28, for a substantial part of the reinforcing portions 27,28, beneath the flanges 11,12.

In this embodiment, the extension parts 29,30, of the reinforcing portions 27,28, are secured by fasteners 40 to the edge portions 22,23, of the web 18, although could be secured by riveting, clinching, stitching, or spot welding, or need not be secured if this is not required.

Referring now to Figures 7a and 7b, views similar to the views shown in Figures 6a and 6b are shown, but of

a further embodiment of a structural member 55 in accordance with the invention.

Again, similar parts of the structural member 55 to those of the preceding figures are shown with the same reference numerals.

In this embodiment, the reinforcing portions 27,28, are provided with integral stiffening comprising stiffening formations being a plurality of separate formations 56 each of which extend in the longitudinal extent of the structural member 55, but the stiffening formations 56, are separated from each other longitudinally and transversely of the structural member 55 via spaces 57.

Referring now to Figure 8a, a yet still further embodiment 58 of a structural member in accordance with the invention is shown. Again similar parts of the structural member 58 to the structural members of the preceding figures are indicated by the same reference numerals.

In this embodiment, the reinforcing portions 27 and 28 which are connected to the box sections 15,16, at the one edges 13,14, of the structural member 58, are again provided with integral stiffening formations 54 like those of Figures 6a, 6b. However, the extension parts 29 and 30 of the reinforcing portions 27,28, which extend generally adjacent and parallel to respective edge portions 22,23, of the web 18, are secured to the respective edge portions 22,23, in this example, by spot welding as indicated at 60 and 61. Spot welds would of course be provided at intervals along substantially the entire length of the structural member 58. Alternatively, the portions 22,23, could be secured to the portions 27,28, by fasteners, clinching, stitching, or rivetting for further examples.

It can be seen that the extension parts 29 and 30 instead of terminating in inturned lips such as illustrated at 31,32, in the preceding Figures, which extend generally perpendicularly to the extension parts 29,30, inturned lips

63 and 64 respectively, extend generally parallel to the respective inclined portions 20 and 21 of the web 18.

The median portion 19 of the web 18 is provided with integral stiffening comprising a plurality of ribs 66 which extend transversely to the longitudinal extent of the structural member 58, as indicated in Figure 8c.

Between the ribs 66, are spaces 67, and in at least some of the spaces 67, apertures 69 are provided to enable connection of, for example, a tie rod 70 to the median portion 19 of the web 18, as indicated. A threaded stud 71 of the tie rod 70 passes through an appropriate aperture 69 and a nut 72 being received on the stud 71 to provide the connection between the tie rod 70 and the median portion 19 of the web 18.

Instead of a tie rod 70, any other transversely extending member could be secured to the median portion 19 of the web in apertures 69 in the median portion of the web 19.

The apertures 69 as shown are circular, although square or other rectangular shaped apertures may be provided if desired, to accommodate different types of fixing of tie rod or other transversely extending member.

In Figure 8b a structural member 73 substantially similar to structural member 58 is shown, but the integral stiffening formations 66 extend along part of the inclined portions 20 and 21 of the web 18. In Figure 8c the extended parts of the stiffening formations 66 are indicated in dotted lines at 74.

Alternative arrangements of integral stiffening of the web 18 are possible for example as indicated in Figure 9, where a waffle configuration of integral stiffening is shown on a structural member 75.

Again similar parts of the structural member 75 to the structural members of the preceding Figures are indicated by the same reference numerals.

In this arrangement, integral stiffening formations are provided as a first set 76 which are located to one side of a plane of symmetry 77 of the structural member 75, and a second set 78 located on an opposite side of the plane of symmetry 77.

The first set of stiffening formations 76 comprise an array of formations and the second set 78 of stiffening formations also comprise an array of formations, the formations 76 and 78 being separated by a space 83 along which are provided apertures 69, to enable the connection of tie rods such as tie rod 70 of Figure 8a, or any other transversely extending member.

In Figure 10, a structural member 85 is indicated in which a first array 76 of stiffening formations are located substantially but not entirely to one side of the plane of symmetry 77, and a second set of stiffening formations 78 are provided as an array substantially but not entirely to the opposite side of the plane of symmetry 77, with apertures 69 being provided along the plane of symmetry 77 in spaces 83 between the stiffening formations 76 and 78.

Referring now to Figure 11, a structural member 86 is shown which is substantially similar to the structural members of the preceding Figures, again similar parts being indicated by the same reference numerals. In this embodiment, the flanges 11 and 12 are provided with respective depressions 87 and 88 in the same region as a longitudinally extending rib 51,52, in the reinforcing portions 27 and 28.

The depressions 87,88, can provide useful location formations for example, for thermal break material, such as sheets of insulation which are located between the flange 11,12, and cladding which may be secured thereto.

It will be appreciated by those skilled in the art that many other variations of a structural member in

accordance with the invention are possible. Figures 12 to 17 illustrate some such variations.

A secondary function, after strength consideration, of the flanges is to receive fasteners to secure, for example, cladding or decking material thereto. These materials are most commonly fastened by means of self-drilling, self-tapping screws. It is necessary, therefore, to provide as much as possible of the flange with an area in which such a fastening can be engaged. If it is attempted to drive such a fastening into an assembly comprising elements which are spaced by a distance less than the overall length of the shank of the fastener and greater than the distance between the tip of the fastener and the first thread it is found that when the tip engages the second element instead of drilling into the second element the elements are forced apart as a result of engagement of the thread with the first element. To avoid this and provide said area in which such a fastener can be engaged the element must be in contact or so closely adjacent or so far apart that the above described forcing apart does not occur. In practical terms the element should be in contact or not spaced by more than 3 - 4mm or be spaced by more than about 15mm. This area should ideally extend over 100% of the width of the flange but certainly no less than 60 - 65% thereof. Otherwise operators find insufficient area in practice in which to engage the fasteners. The embodiment shown in Figures 12n, o, p, 14c and 15b are preferred forms from this point of view. These embodiments are also preferred because the shape of the reinforcing portion has been found by our test work unexpectedly to be beneficial in increasing the efficiency of the section in bending. In some configurations such as that shown in Figure 12f it is important that the gap between the flange and the reinforcing portion is such that a self-drilling, self-

tapping screw can be fixed so that it does not force the two elements apart as described above. This means in practice that the gap between the flange and the reinforcing portion should exceed about 15mm.

If desired the reinforcing portion may be disposed on the outside of the flange. A corresponding "external" disposition of the reinforcing portion may be provided for other embodiments where this is practicable.

Each of the structural members described could be modified by the inclusion of a feature or features shown and/or described in relation to any other structural member.

The forms of stiffening formations described are preferably all achieved by deformation of the material during the cold rolling process, although may otherwise be achieved as desired.

Various other forms of and arrays of stiffening formations are possible to those described with reference to and as shown in the accompanying drawings.

The structural members shown in the Figures can be of any desired proportions, for example the web 18 may comprise a substantially smaller median portion 19, with correspondingly longer inclined portions 20 and 21 and edge portions 22,23. Alternatively, the edge portions 22,23, of the web 18 may be substantially smaller than shown with the median portion 19 and/or inclined portions 20,21, correspondingly longer.

Instead of the closed sections 15,16, at the one edges 13,14, of the flanges 11,12, comprising box sections, a substantially closed section of any other desired configuration could be provided e.g. circular, oval, triangular, trapezoidal. Further, the closed section could be of other proportions to that shown.

Each closed section may comprise a first portion which extends from the associated flange 11, 12 generally

towards the other flange 12, 11 respectively, a second portion which extends from the first portion at the end thereof remote from the associated flange towards the web 18 and a third portion which extends from the end of the second portion remote from the first portion towards the associated flange. One or more of the above mentioned portions may be rectilinear or curvilinear in cross-section and where a portion is rectilinear it may extend at right-angles to the associated flange or adjacent portion or be inclined thereto at other than 90°. Preferably, the third portion extends over a majority of the distance from the end of the second portion to the associated flange and more preferably over at least 75% of the distance.

A reinforcing portion such as the portion 27, 28 may extend from the end of the third portion closest to the associated flange. The reinforcing portion may extend over at least the majority of the distance from the end of the third portion towards the web and preferably over at least 75% of the distance.

Preferably each reinforcing portion has an extension part which extends from the end of the reinforcing portion towards the other flange.

The extension part may extend over a distance equal to the whole or part of the edge portion 22, 23 of the web 18 and may have an inturned lip 31, 32 which may extend in the direction away from the web over a distance at least equal to the majority of the length of the extension part.

In a structural member in accordance with the invention, a structural beam may be provided which need not have reinforcing portions 27,28.

The dimensions of the reinforcing formation are important if the section is to perform to its maximum efficiency. The maximum depth, D, of the reinforcing formation should preferably lie in the range 10 - 30% of the width, F, of the flange. The maximum width, W, of the

reinforcing formation should preferably lie in the range 8 - 25% of the width, F, of the flange. In the Figures the dimensions D, F, and W are shown only in Figures 12a, 12f, 12g, 13a and 13b for convenience, although it would be appreciated that the analogous dimensions apply in the other Figures.

The angle between the intermediate portion of the web and the associated edge portions and the median portion has been found to be preferably between 160° and 150° for best section performance and most preferably 157°. This angle can be made smaller than the above mentioned range if necessary for adjustment of the section shear centre position.

The extension part has been found to be most efficient if it extends over the full depth of the web edge portion and thus terminates at the junction between the edge and intermediate web portions.

Although in all the illustrated examples the intermediate web portion has been shown as being inclined to the adjacent edge and median web portions and preferably to lie in the range 160° to 150° as mentioned above, if desired the intermediate portion may be inclined to the edge and median web portions at, for example, 90° or at an acute angle if desired.

Utilising the invention, the strength of the structural member can be maintained or even enhanced, without having to increase particularly, the thickness of the material of the web 18, thus saving material.

In the embodiment illustrated the reinforcing formation may have a height lying in the range 10mm - 30m and a width lying in the range 10mm to 30mm.

By adopting a construction of structural member in accordance with the invention the overall thickness of the material of the structural member can be decreased from what is considered to be the minimum with a conventional

structural member of this kind for a given use, whilst maintaining the strength of the structural member overall.

In structures embodying the invention no reinforcing structures, webs, gussets or the like are required between the flanges or between the flanges and the web. Moreover, no welding operation is required thereby permitting the use of coated materials such as galvanised steel without surface damage.

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, or a class or group of substances or compositions, as appropriate, may, separately or in any combination of such features, be utilised for realising the invention in diverse forms thereof.

CLAIMS:

1. A structural member of the kind specified wherein at least one of the flanges has a reinforcing formation at least at one edge, the reinforcing formation comprising a generally closed section connected to the one edge of the respective flange.

2. A member according to Claim 1 wherein the flanges comprise side by side generally opposed flanges disposed on the same side of the web.

3. A member according to Claim 1 or Claim 2 wherein the flanges comprise flanges disposed on opposite sides of the web.

4. A member according to any one of the preceding claims wherein the closed section extends generally throughout the length of the structural member and is selected from the group comprising, a square or rectangular box section, a circular, oval, triangular or trapezoidal in cross section box section.

5. A member according to any one of the preceding claims wherein the maximum depth of the reinforcing formation lies in the range 10 - 30% of the width of the flange and/or the maximum width of the reinforcing formation lies in the range 8 - 25% of the width of the flange.

6. A member according to any one of the preceding claims wherein the reinforcing formation is of greater width at a position spaced from the flange than it is at the flange.

7. A member according to Claim 6 wherein the reinforcing formation defines a groove between the flange and the surface of the reinforcing formation which is closest to the web.

8. A member according to any one of the preceding claims wherein the reinforcing formation comprises a first portion which extends from the associated flange generally towards the other flange, a second portion which extends from the first portion at the end thereof remote from the associated flange towards the web and a third portion which extends from the end of the second portion remote from the first portion towards the associated flange.

9. A member according to Claim 8 wherein one or more of the above mentioned portions is rectilinear in cross-section.

10. A member according to Claim 9 wherein where a portion is rectilinear it extends at right-angles to the associated flange or adjacent portion.

11. A member according to Claim 8 wherein one or more of the above mentioned portions is curvilinear.

12. A member according to Claim 8 wherein the first and second portions are rectilinear and extend at 90° to the associated flange and the first portion respectively whilst the third portion is rectilinear and is inclined to the second portion at an acute angle.

13. A member according to Claim 12 wherein the third portion extends from the second portion to a position adjacent the associated flange which is adjacent the

position at which the first portion leaves the associated flange.

14. A member according to any one of the preceding claims wherein both of the flanges have a reinforcing formation comprising a generally closed section at their respective one edges.

15. A member according to any one of the preceding claims wherein the closed section reinforcing formation is connected to a reinforcing portion at least a part of which extends generally adjacent and parallel to the respective flange.

16. A member according to Claim 15 wherein each reinforcing formation is connected to a reinforcing portion.

17. A member according to Claim 15 or Claim 16 wherein the reinforcing portion comprises a double thickness flange or flange and web part.

18. A member according to any one of Claims 15 to 17 wherein the reinforcing portion comprises a part of the reinforcing formation.

19. A member according to Claim 18 wherein the reinforcing formation comprises a rectangular box section and one side of the box is provided by the flange and an opposite side of the box by the reinforcing portion.

20. A membert according to any one of the preceding claims wherein each of the flanges has an associated reinforcing portion.

21. A member according to any one of Claims 15 to 20 wherein the or each reinforcing portion terminates in the region of the connection between the edge portions and the connected inclined portions of the web.

22. A member according to any one of Claims 15 to 21 wherein the reinforcing portion comprises integral stiffening.

23. A member according to Claim 22 wherein the integral stiffening is provided by one or more stiffening formations comprising ribs which extend longitudinally of the structural member generally over the entire length thereof.

24. A member according to Claim 22 wherein the integral stiffening is provided by stiffening formations comprising transversely extending ribs.

25. A member according to Claim 22 wherein the integral stiffening is provided by an array of stiffening formations arranged in any desired pattern over the reinforcing portion.

26. A member according to any one of Claims 23 to 25 wherein the or each of the stiffening formations is provided by material of the reinforcing portion deformed out of the plane of the remainder of the reinforcing portion in an eventual direction preferably away from the adjacent flange.

27. A member according to any one of Claims 15 to 26 wherein the reinforcing portion extends generally adjacent and parallel to the respective flange, along the side of the flange facing inwardly of the structural member.

28. A member according to any one of Claims 15 to 26 wherein the reinforcing portion extends generally adjacent and parallel to the respective flange along the side of the flange facing outwardly of the structural member.

29. A member according to any one of Claims 15 to 28 wherein the reinforcing portion terminates at an edge adjacent the respective flange.

30. A member according to any one of Claims 15 to 28 wherein the reinforcing portion comprises an extension part which extends generally adjacent and parallel to a part of the web.

31. A member according to Claim 30 wherein the extension part extends throughout the full depth of the associated edge portion of the web, thus terminating at or adjacent the junction of the web edge and intermediate portions.

32. A member according to any one of Claims 15 to 31 wherein the reinforcing portion terminates in an inturned lip if desired.

33. A member according to any one of Claims 15 to 32 wherein the reinforcing portion is connected to the respective flange or to the web if desired.

34. A member according to Claim 33 wherein where an extension part is provided, this may be secured to the web.

35. A member according to any one of the preceding claims wherein the web is provided with integral stiffening.

36. A member according to Claim 35 wherein strengthening of the web is achieved by providing stiffening formations which are deformed out of the plane of at least the median portion of the web.

37. A member according to Claim 36 wherein the integral stiffening comprises one or more stiffening formations comprising ribs which extend generally throughout the length of the structural member along the median portion.

38. A member according to Claim 36 wherein the integral stiffening comprises one or more stiffening formations or comprises a series of ribs arranged transversely of the longitudinal extent of the structural member.

39. A member according to Claim 35 wherein the integral stiffening comprises a first set of stiffening formations arranged generally to one side of a plane of symmetry of the structural member and a second set of stiffening formations arranged generally to the other side of the plane of symmetry of the structural member.

40. A member according to Claim 35 wherein a space is provided generally between the first and second sets of integral stiffening formations in which are provided openings for another element.

41. A member according to Claim 35 wherein the integral stiffening is provided by an array of stiffening formations provided at least in the median portion of the web, there being areas generally along the plane of symmetry of the structural member where no stiffening formations are provided, but in which apertures are provided through the median portion of the web for another element.

42. A member according to any one of the preceding claims wherein the flange has a portion which extends over at least 60% of the total flange width which is of single thickness or of double thickness with the inner and outer flange parts in the double thickness region in contact or closely adjacent.

43. A member according to any one of the preceding claims wherein each intermediate portion is inclined at 90° to the edge portion and the median portion.

44. A member according to any one of Claims 1 to 42 wherein each intermediate portion is inclined at an obtuse angle to the edge portions and the median portion.

45. A member according to Claim 44 wherein the obtuse angle lies in the range 160° to 150°.

46. A member according to any one of the preceding claims wherein the structural member is of non-welded construction.

47. A member substantially as hereinbefore described in any one or more of the accompanying drawings.

48. A structure comprising at least two support members and a structural member according to any one of Claims 1 to 47 supported by and extending between the support members and being connected to each of the support members by load bearing members comprising cleats, one cleat being fixed to each of the two support members.

49. A structure according to Claim 48 wherein the structural member is connected to a load bearing member by

fasteners which are engaged with a reinforcing portion of the structural member.

50. A structure according to Claim 49 wherein the load bearing member comprises a cleat, a rafter stay, a joining sleeve or any other member for taking loads into or out of the structural member.

51. A structure according to any one of Claims 48 to 50 wherein the load bearing member is fastened to the structural member by fasteners which are engaged with the edge portions of the web of the structural member.

52. A structure according to any one of Claims 48 to 51 wherein the structural member comprises an extension part of the reinforcing formation which is secured to the web by a fastener which fastens the cleat to the structural member.

53. A structure substantially as hereinbefore described with reference to any one or more of the accompanying drawings.

54. Any novel feature or novel combination of features disclosed herein and/or in the accompanying drawings.

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